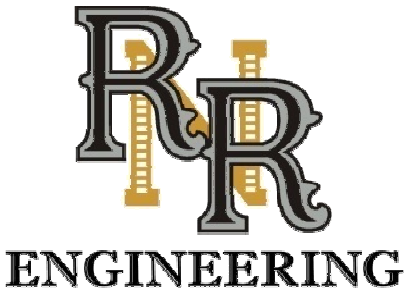
Obtaining Consistent Deicing Results Using Automation and Proven Technology



Agenda

- Government Regulations on De-Icing
- Proposed Improvements
  - EPA, NTSB, OSHA
- Deicing/Anti-Icing Process Today
- RNR Engineering Innovations
- ATS Performance Capabilities
- Questions and Answers

ENGINEERING

Government Regulations

- Clean Aircraft Concept
- Contaminant Removal
- Human Visual Inspection
- International Deicing Guidelines

Regulations referenced from: Federal Aviation Regulations 91.525-91.529 and 121.629

ENGINEERING

Government Regulations

- **1000.B** If the pilot, or group of associated pilots becomes aware of, or realizes, or detects, or discovers or finds that he, or she, or they, are or have been beginning to understand the Federal Aviation Regulations, they must immediately, within three (3) days notify, in writing, the Administrator.

Regulations referenced from: Federal Aviation Regulations 91.525-91.529 and 121.629

ENGINEERING

Government Regulations

ENGINEERING

Government Regulations

The EPA passed Effluent Guidelines in 2004 requiring better treatment and restricting the amount of Deicing/Anti-Icing fluids used on aircraft

ENGINEERING

EPA Proposed Improvements

- 60% Deicing fluid collection by airports using 460,000 gallons or more.
- 20% Deicing fluid collection by smaller airports.
- Centralized Deicing pad for recollection

EPA requests referenced from:
http://www.epa.gov/guide/airport/airport_ea_proposed_2009.pdf.

ENGINEERING

NTSB Proposed Improvements

One of the top requested improvements on the NTSB's "Most Wanted" Aviation Safety Improvements List since 1990 is

"Improve the Deicing/Anti-icing process to make airport staff and passengers safer"

ENGINEERING

NTSB suggested improvements referenced from:
http://www.ntsb.gov/recs/brochures/MostWanted_2009.pdf

OSHA Requirements

- Exposure to bad weather and harsh conditions and Deicing/Anti-Icing fluids *must be limited*
- Deicing equipment manufacturers operational limits must be followed

EPA requests referenced from:
http://www.epa.gov/guide/airport/airport_ea_proposed_2009.pdf.

ENGINEERING

Deicing and Anti-icing Today…

Deicing and Anti-icing Today…

- **Overspray:**

  Lack of sensors and automation cause over spray

- **Under spray:**

  Large distances from deicing nozzles to aircraft surface, bad weather cause flight critical areas to be improperly deiced

- **Fugitive Glycol:**

  The large distances from nozzles to aircraft surfaces combined with bad weather create large clouds of fugitive glycol. These clouds harm the environment and do nothing to deice the aircraft

ENGINEERING

Deicing and Anti-icing Today…

- It can take as long as 60-90 minutes to deice and anti-ice an aircraft[1]

- **Anti-icing fluids on average last 5-35 minutes**. If layover time is longer than 35 minutes, removal of previous anti-icing fluid and application of new fluid is required[2]

[1] http://www.wingsmagazine.com/content/view/1325/38/ , Infrared giving glycol a run for its money

[2] FAA holdover tables

ENGINEERING

Deicing and Anti-icing Today…

10-15 minutes repositioning (per aircraft side):

- Estimated 30 to 60 seconds to drive up to plane
- 60 to 120 seconds to travel from tip of wing to first engine
- 45 to 120 seconds to move around engines
- 60 to 120 seconds to travel from engine to fuselage
- 120 to 360 seconds to position at tail

ENGINEERING

Truck Platform

Truck Platform Challenges

Truck Specifications

- Max. ground to eye level 37.7 feet.
- Max. ground to nozzle height 63 feet.
- Max. tank capacity 2600 gallons

Aircraft Specifications

- Max. wing height 35 feet
- Max. tail height 70 feet
- Max. wing length 250 ft.

[1] Truck specifications referenced from http://www.g-vestergaard.dk/de-icing/beta.html

[2] Aircraft specifications referenced from http://www.airliners.net

ENGINEERING

Fixed Gantry Platform

Fixed Gantry Platform Challenges

- Large capital investment
- Bottleneck for plane traffic
- Large one use footprint
- Unable to reach underside of aircraft
- Mobile systems still necessary during extreme weather conditions

Gantry Information referenced from:
http://www.epa.gov/waterscience/guide/airport/airport.pdf, UPS and European Airlines

ENGINEERING

Today's methods will not meet Tomorrow's standards

Deicing Challenges

- Decrease distance of operator and spray nozzle to all flight critical surfaces
- Increase speed in the application of de-icing and anti-icing fluids
- Increase accuracy and precision in the application of de-icing and anti-icing fluids
- Decrease consumption of de-icing and anti-icing fluids to FAA and EPA standards

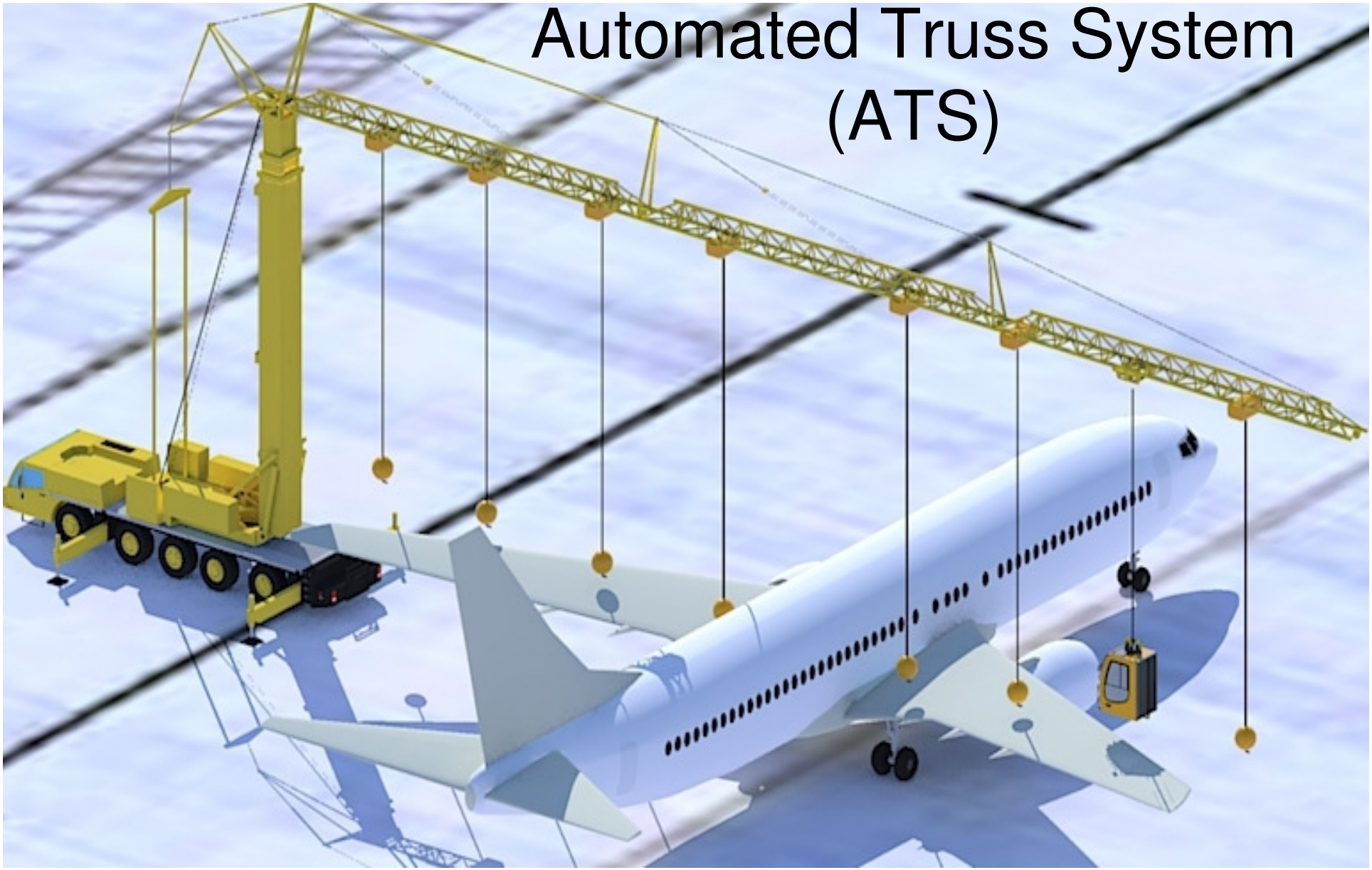
ENGINEERING

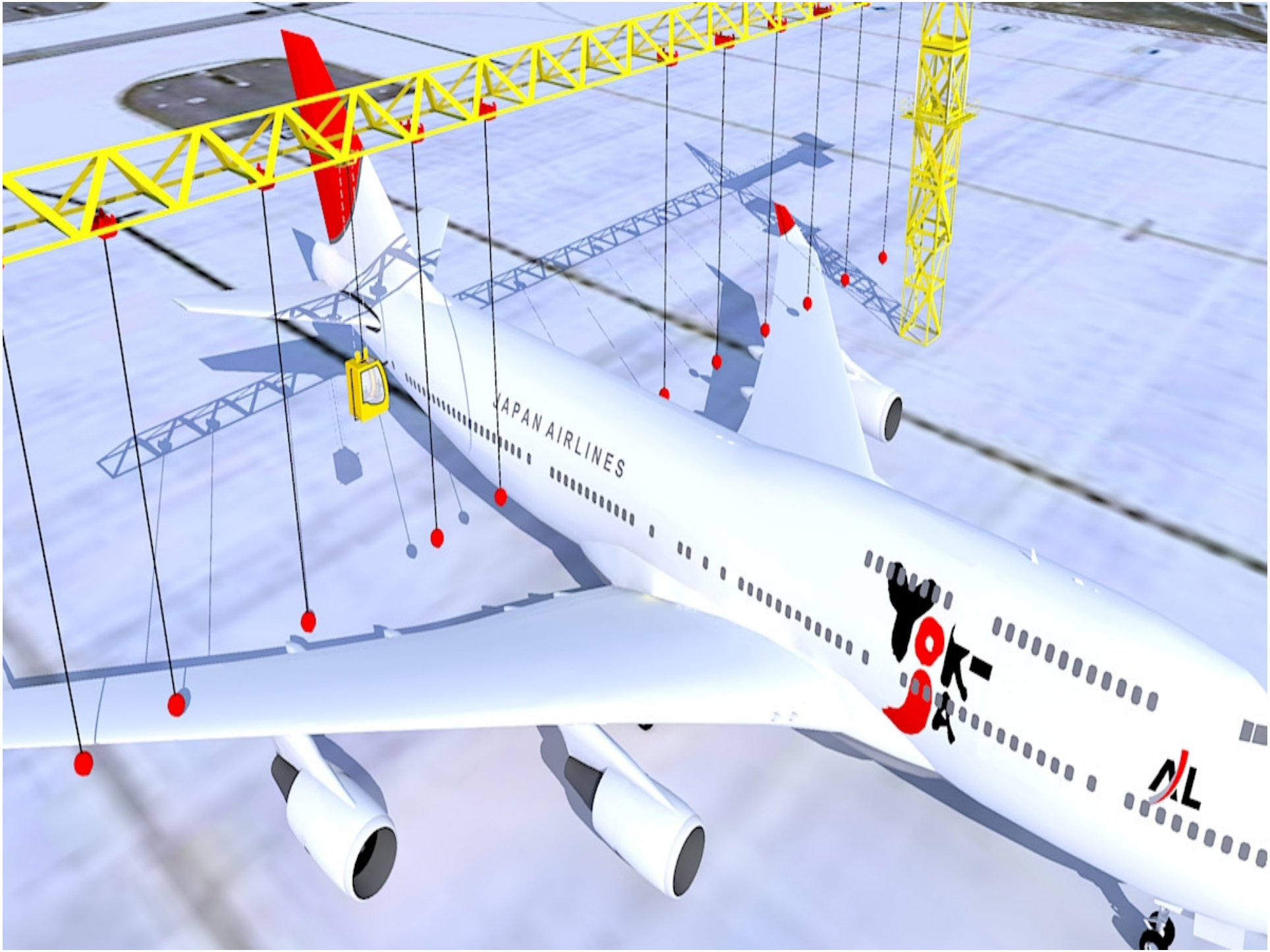
Deicing Challenges

- Minimize repositioning
- Reduce labor, equipment, and land requirements for de-icing and anti-icing aircraft
- Increase operator safety

RNR Engineering Innovations

Automated Truss System (ATS)




JAPAN AIRLINES

RNR Engineering Innovations

De-icing and anti-icing systems deployed over flight critical surfaces using an automated process that *maps out surfaces* to be de-iced and applies de-icing and anti-icing fluids where necessary

ENGINEERING

RNR Engineering Innovations

Automated process utilizing standard video recording cameras, infrared cameras, computer controlled nozzles and proven software to ensure that aircraft is completely de-iced and anti-iced

ENGINEERING

Platform Innovations

- Designed to reduce repositioning
    - (Rotates over plane eliminating reaching up and across plane)
- Proven technology for precise accurate movement of equipment within inches of fragile objects
    - (Glass windows and construction work)

ENGINEERING

Platform Innovations

- Eliminates bottlenecks
  - (Allows for two lane operation per machine)
- Stand alone, self erecting, mobile options make it scalable for any airport
- Improves Inspection and Quality Assurance
  - (Operators get within inches of flight critical surfaces)

ENGINEERING

LIDAR (Light Detection and Ranging)

- Produces shapes, contours, and height changes of aircraft surfaces
  - (Insures efficient deicing by highlighting highest areas of surfaces to be deiced)
  - (Insures all contours of flight critical surfaces deiced by displaying them.)

- Produces clear contrast between aircraft surfaces and the ground
  - (Combined with edge detection software and computer controlled nozzles eliminate chance of spraying deicing fluid directly onto ground)

ENGINEERING

Infrared Temperature Mapping

- Produces temperature map of flight critical surfaces
    - (Insures safe deicing by pointing out “cold spots” of aircraft that need special attention)
- Produces temperature map of applied layer of anti-icing fluid
    - (Pinpoints potential weak spots in anti-icing layer)
    - (Insures efficient anti-icing fluid application by showing flight critical surfaces not yet anti-iced)

ENGINEERING

Technology Innovations

- Sensors map tomography and topography of aircraft
  - (LIDAR mapping systems)
  - (Infrared Range Measurement and i Sensors make 3D map of Plane, used in other industries)
- Automated nozzles insure accurate and precise fluid application.
  - (Computer Controlled Nozzle)
- Edge detection system and proximity sensors insure safe, consistent, and reliable aircraft Deicing/Anti-Icing
  - (Industry Proven Software)
  - (Edge detection insures fluid applied only to aircraft)

ENGINEERING

Technology Innovations

- Video Cameras and on board computers keep record of each unique aircraft serviced from amount of fluids used to a video recording of the entire Deicing/Anti-Icing Process.
    - (Security and CCTV cameras designed to operate in harsh conditions, industry proven technology)

- **<u>All accomplished with hardware and software on the market today</u>**

ENGINEERING

Deicing Challenges Overcome

- Reduced Fluid Consumption (Spray methods and proximity to plane)
- Fluid Application (Distance from plane, maneuverability, full automation with human inspection, more precise nozzle control)
- Minimize Repositioning (Structure choice)
- Distance from nozzle and operator to flight critical surfaces decreased (structure choice)

ENGINEERING

Deicing Challenges Overcome

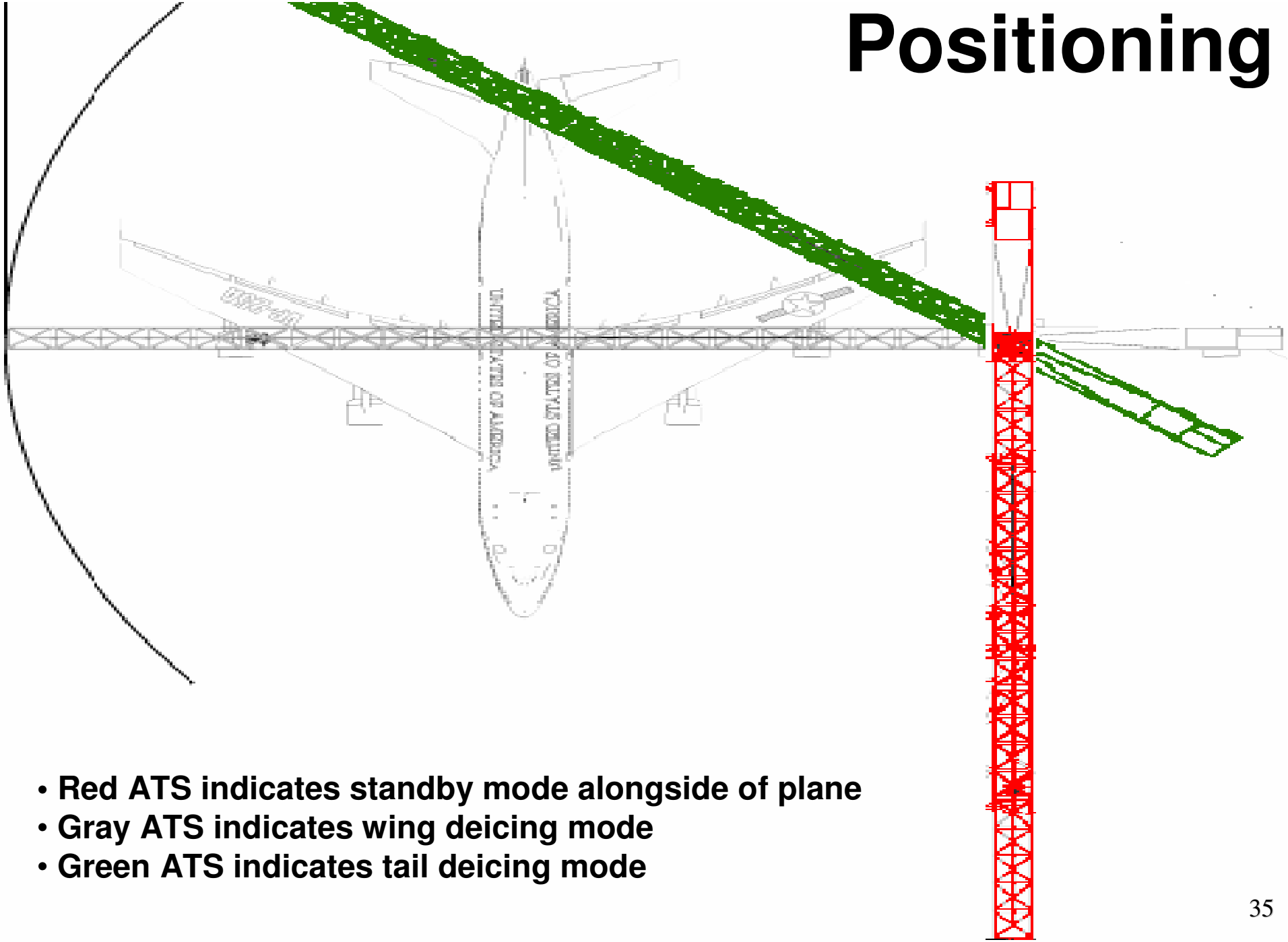
- Increased operator safety (closed cabs, limited contact with deicing fluids)
- Increased fluid application accuracy (sensors, LIDAR, infrared)
- Increased fluid application rate (structure choice, sensors, multiple nozzles)

Government Agencies Satisfied

ENGINEERING

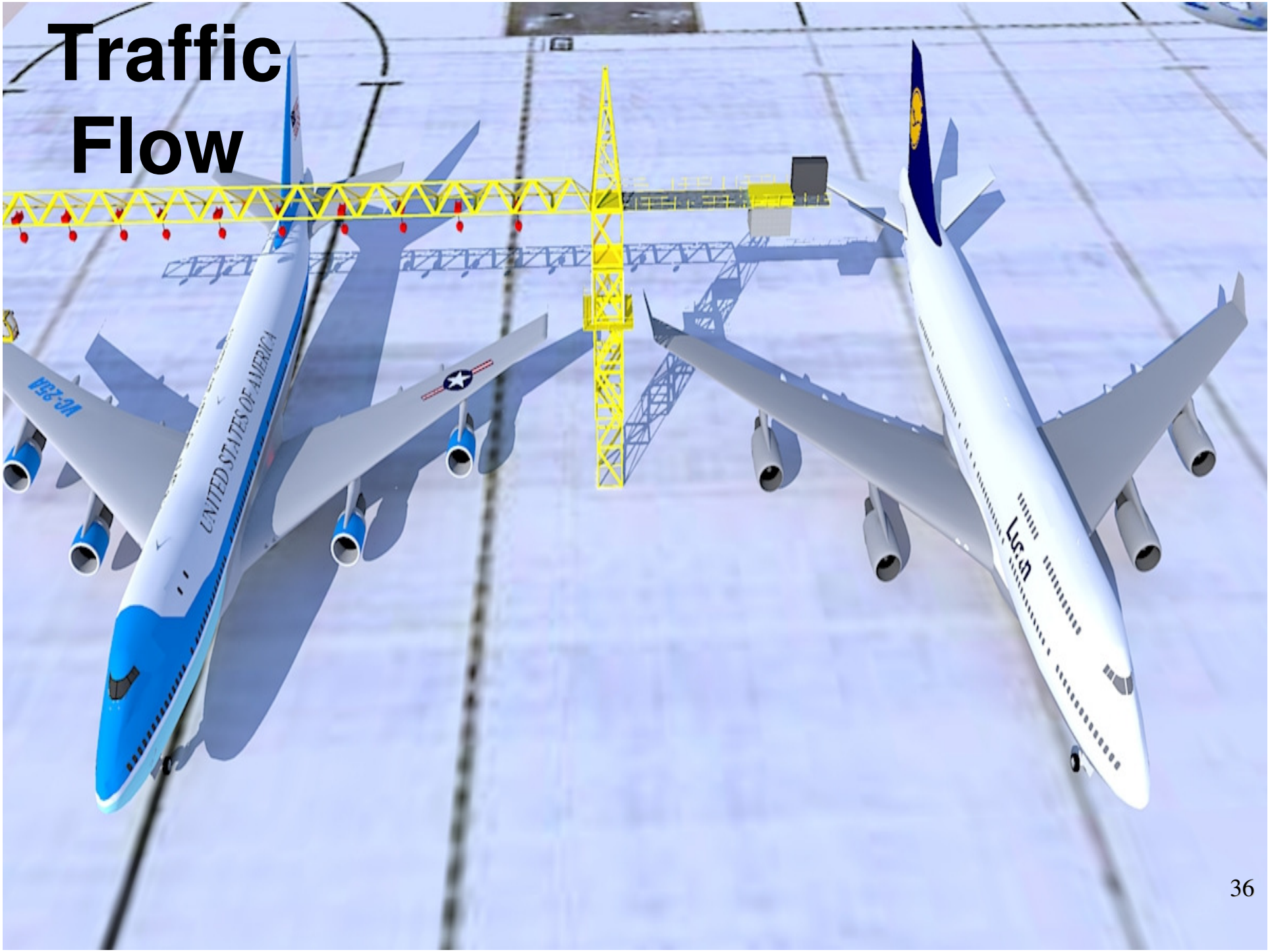
ATS Performance Capabilities

Positioning



- Red ATS indicates standby mode alongside of plane
- Gray ATS indicates wing deicing mode
- Green ATS indicates tail deicing mode

Traffic Flow



ATS Positioning

ATS	Comparison	Current System
less than 1 minute	Total Positioning Time	9 to 23 minutes
less than 30 seconds	Position To Wings	1 to 2 minutes
0 seconds	Repositioning Around Wings	5 to 15 minutes
10 to 15 seconds	Position to Tail	1 to 2 minutes
0 seconds	Repositioning around Tail	2 to 4 minutes
Yes	Aircraft Mapping Software	No
Yes	Edge Detection Software	No
Yes	Temperature Mapping Software	No
6 to 24 inches	Distance from Flight Critical Surfaces	2 to 10 feet
80 feet	Maximum Eye Height for Inspection	38 to 51 feet

- **This increases: Throughput of aircraft, Window of time before plane must either takeoff or be deiced again, Efficiency of entire deicing process**
- **The increased operator height and decreased distance from operator to aircraft provide better inspection capabilities improving overall safety.**

ENGINEERING

Flow Rate

ATS	Comparison	Current System
60 gpm (0.003875 m3/s)	Deicing Flow Rate	60 gpm (0.003875 m3/s)
20 gpm (0.001292 m3/s)	Anti-Icing Flow Rate	20 gpm (0.001292 m3/s)
4	Operating Nozzles	1

•The industry accepted standards for deicing and anti-icing flow rates are 60 gpm and 20 gpm, respectively

•The ATS implements 4 nozzles simultaneously to ensure a more uniform application of fluid to improve the efficiency and safety of the current process.

ENGINEERING

Temperature

ATS	Comparison	Current System
Between 140°F (60°C) and 194°F (90°C)	Deicing Fluid Temperature at Nozzle	Between 140°F (60°C) and 194°F (90°C)
Between 6 inches to 2 feet	Distance from Nozzle to Aircraft	Between 5 feet and 10 feet
212°F (100°C)	Fluid Temperature Limit	194°F (90°C)

- **The FAA requires at least 140°F (60°C) fluid temperature at nozzle**
- **The ATS meets both the FAA and individual fluid manufacturer's performance standards for fluid temperature.**
- **The ATS applies fluids at higher temperatures to the aircraft surface further improving the deicing process.**

ENGINEERING

Pressure

ATS	Comparison	Current System
20 psi (0.34 MPa)	Standard Anti-Icing Operating Pressure	20 psi (0.34 MPa)
150 psi (1.03 MPa)	Standard Deicing Operating Pressure	150 psi (1.03 MPa)
1000 psi (6.89 MPa)	Maximum Operating Pressure	150 psi (1.03 MPa)
4	Nozzles in Operation	1

•The industry accepted standards for Deicing and Anti-Icing are 150 psi and 20 psi respectively

•The ATS easily meets and exceeds the industry standard of 150 psi for deicing and 50 psi for anti-icing.

•With 4 nozzles in operation simultaneously, the ATS deices faster and more efficiently than any current system on the market.

ENGINEERING

Wind

Situation	Operational Range
Current System Operational Wind Speed Limit	30 mph (13.4 m/s) to 45 mph (20.1 m/s)
ATS Operational Wind Speed Limit	45 mph (20.1 m/s)
ATS Nozzle Sway with 45 MPH Wind	0.7 feet (0.2 meters)
ATS Cab Sway with 45 MPH Wind	0.8 feet (0.2m)
Percent of time Wind Speeds are at or below 45 MPH	98.10%
Percent of Time Wind Speeds are above 45 MPH	1.90%

- **The ATS comes equipped with PID (Proportional Integral-Derivative) Controllers which redirect the nozzle to compensate for any sway.**
- **Sway of the nozzles does not affect the desired temperature, pressure, and flow rate of the fluid.**

ENGINEERING

Thank you for your time!

Questions?

ENGINEERING
1111 Superior Avenue, Suite #1335
Cleveland, OH 44114
440-557-5087